



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : <b>H04N 5/74</b>	<b>A1</b>	(11) International Publication Number: <b>WO 00/60857</b> (43) International Publication Date: 12 October 2000 (12.10.00)
<p>(21) International Application Number: PCT/US00/09462</p> <p>(22) International Filing Date: 10 April 2000 (10.04.00)</p> <p>(30) Priority Data: 60/128,613 8 April 1999 (08.04.99) US</p> <p>(71) Applicant (for all designated States except US): INTERNET PICTURES CORPORATION [US/US]; Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US).</p> <p>(72) Inventors; and</p> <p>(75) Inventors/Applicants (for US only): BAUER, Martin, L. [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). COLE, Bruce [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). EVANS, Kimberly, S. [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). GRANTHAM, Craig [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). JACKSON, P., Laban [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). KING, Christopher, M. [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US).</p>		<p>KITZMILLER, Sean [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). KUBAN, Daniel, P. [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). MARTIN, H., Lee [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). TOURVILLE, Michael, J. [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). ZIMMERMANN, Steven, D. [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). HATMAKER, James, L. [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). MCGINNIS, Sean, W. [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US). GOURLEY, Christopher, Shannon [US/US]; Internet Pictures Corporation, Suite 100, 1009 Commerce Park Drive, Oak Ridge, TN 37830 (US).</p> <p>(74) Agents: GLEMBOCKI, Christopher, R. et al.; Banner &amp; Witcoff, Ltd., 11th floor, 1001 G Street, N.W., Washington, DC 20001-4597 (US).</p> <p>(81) Designated States: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</p>
(54) Title: VIRTUAL THEATER		
<p>(57) Abstract</p> <p>A method and apparatus for projecting perspectively corrected spherical video images in a theater environment is disclosed. First, video signals and associated audio signals are stored (14). The direction of view of a user is then tracked (60, 62) to create sufficient feedback information which is then provided to a processor (50). The video signals and audio signals are then provided to the processor (50). The processor then orients the video signal based on the position feedback information and then perspectively corrects the video signal. The audio signal is oriented based on the orientation of the perspectively corrected video signal. The perspectively corrected video signal and the oriented audio signals are then provided to a projection system (64), wherein the perspectively corrected video signals are projected on a screen and said oriented audio signals create an impression of a three-dimensional sound field.</p>		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon	KR	Republic of Korea	PL	Poland		
CN	China	KZ	Kazakhstan	PT	Portugal		
CU	Cuba	LC	Saint Lucia	RO	Romania		
CZ	Czech Republic	LI	Liechtenstein	RU	Russian Federation		
DE	Germany	LK	Sri Lanka	SD	Sudan		
DK	Denmark	LR	Liberia	SE	Sweden		
EE	Estonia			SG	Singapore		

## VIRTUAL THEATER

**Related References**

This application claims the benefit of U.S. Provisional Application No. 60/128,613, filed on April 8, 1999, which is hereby entirely incorporated herein by reference. In addition, the following disclosures are filed herewith and are expressly incorporated by reference for any essential material:

1. U.S. Patent Application Serial No. \_\_\_\_\_, (Attorney Docket No. 01096.86946) entitled "Remote Platform for Camera";
2. U.S. Patent Application Serial No. \_\_\_\_\_, (Attorney Docket No. 01096.86949) entitled "Maethod and Apparatus for providing Virtual Processing Effects for Wide-Angle Video Images";
3. U.S. Patent Application Serial No. \_\_\_\_\_, (Attorney Docket No. 01096.84594) entitled "Immersive Video Presentations".

**Field of the Invention**

The present invention relates to a method and apparatus for displaying perspectively corrected spherical video images, and more particularly to displaying the perspectively corrected spherical video images in an orientation specified by a viewer wherein the audio signal broadcast along with the video signal creates an impression of a three-dimensional sound field which is oriented in the same orientation as the video signals.

**Background of the Invention**

The fundamental apparatus, algorithm and method for achieving perspectively corrected

views of any selected portion of a hemispherical (or other wide-angle) field of view are described in detail in U.S. Patent No. 5,185,667. This patent along with U.S. Patent Nos. 5,359,363, 5,384,588, 5,990,941, and 6,002,430 are incorporated herein by reference for their teachings. Through the use of this technology, no moving parts are required for achieving pan, tilt and rotation "motions", as well as magnification. Briefly, a wide-angled field of view image is captured into an electronic memory buffer. A selected portion of the captured image containing a region of interest is transformed into a perspective corrected image by an image processing center. This provides direct mapping of the wide-angle image region of interest into a corrected image using an orthogonal set of transforming algorithms. The viewing orientation and other viewing parameters are designated by a command signal generated by either a human operator or a form of computerized input. Transformed image is deposited in a second electronic buffer where it is then manipulated to produce the output image as requested by the command signal.

Various spherical and panoramic projection systems are known in the art. For example, various spherical and panoramic display systems are disclosed in U.S. Patent No. 4,656,506, U.S. Patent No. 5,130,792 and U.S. Patent No. 5,495,576 to Curtis J. Ritchey. The images displayed in these projection systems are gathered from a plurality of cameras. However, these systems do not disclose perspective correcting the spherical video images as taught in U.S. Patent No. 5,185,687. Furthermore, the projection or display systems disclosed in the Ritchey patents do not disclose a sound system in which a three-dimensional sound field is created based upon the images being projected.

Systems for creating three-dimensional sound fields are known in the art. Example, Aureal

Semiconductor, Inc., has software available for creating three-dimensional sound fields. Some of the aspects involved with creating three-dimensional sound fields are disclosed in U.S. Patent No. 5,596,644, U.S. Patent No. 5,729,612, U.S. Patent No. 5,802,180, and U.S. Patent No. 6,009,178 all of which are assigned to Aureal Semiconductor, Inc. These patents are specifically incorporated herein by reference. However, these systems have not been used in conjunction with spherical or panoramic projection systems to create a unique environment in which perspectively corrected spherical video images are displayed on a screen and three-dimensional sound fields corresponding to the orientation of the perspectively corrected images are created within the environment.

#### Summary of the Invention

It is an object of the present invention to provide a theater environment in which the view perspectively corrected spherical video images wherein the audio signals associated with the video signals create a three-dimensional sound field wherein the sound field is oriented based upon the orientation of the perspectively corrected spherical video images.

According to one embodiment of the present invention, a method for projecting perspectively corrected spherical video images in a theater environment is disclosed. First, video signals and associated audio signals are stored. The direction of view of a user is then tracked to create sufficient feedback information which is then provided to a processor. The video signals and audio signals are then provided to the processor. The processor then orients the video signal based on the position feedback information and then perspectively corrects the video signal. The audio signal is oriented based on the orientation of the perspectively corrected video signal. The perspectively

corrected video signal and the oriented audio signals are then provided to a projection system, wherein the perspectively corrected video signals are projected on a screen and said oriented audio signals create an impression of a three-dimensional sound field.

According to a second embodiment of the invention, the video and audio signals are projected to a user through a head-mounted display, a projection system enveloping at least a portion of the user's head, or goggles. Audio portions are also projected in each situation.

#### **Brief Description of the Drawings**

The above mentioned features of the invention will become more clearly understood from the foregoing detailed description of the invention read together with the drawings, in which:

Figures 1A and 1B show schematic block diagram of the signal processing portion of the present invention illustrating the major components thereof. Figure 1A shows the perspective correction process implemented in hardware. Figure 1B shows a perspective correction process implemented in software, operating inside in a personal computer.

Figure 2 is a schematic diagram of an image projection system according to one embodiment of the invention.

Figure 3 is a flow chart illustrating a method for projecting perspectively corrected spherical video images in a theater environment according to one embodiment of the invention.

Figures 4A-4G illustrate various screens on which the perspectively corrected spherical video images can be projected according to different embodiments of the invention.

Figure 5 relates to different sound sources and distances to the sources based on the level of

zoom in accordance with embodiments of the present invention.

### **Detailed Description**

The invention relates to a display apparatus for projecting a stream of video images on a screen. As will be explained in detail below, spherical video images are created which allow a user to look in any direction while watching a video presentation. The direction of view of the user is determined and the spherical video images in the general direction of the user's selection are perspectively corrected in such a manner so that the user is looking at perspectively corrected video images even as the user's selected direction of view changes. The display apparatus also comprises a sound system which generates audio signals in such a manner to create an impression of a three-dimensional sound field that is oriented to correspond to at least a portion of the projected video signals.

The principles of the optical transform utilized in the present invention can be understood by reference to the system 10 of Figures 1A and 1B. (This is also set forth in the aforecited U.S. Patent No. 5,185,667 that is incorporated herein by reference.) Referring to Figure 1A, shown schematically at 11 is a wide angle, e.g., a hemispherical, lens that provides an image of the environment with a 180 degree or greater field-of-view. The lens is attached to a camera 12 which converts the optical image into an electrical signal. These signals are then digitized electronically 13 and stored in an image buffer 14 within the present invention. An image processing system consisting of an X-MAP and a Y-MAP processor shown as 16 and 17, respectively, performs the two-dimensional transform mapping. The image transform processors are controlled by the

microcomputer and control interface 15. The microcomputer control interface provides initialization and transform parameter calculation for the system. The control interface also determines the desired transformation coefficients based on orientation angle, magnification, rotation, and light sensitivity input from an input means such as a joystick controller 22, computer input means 23 or some other input device. The transformed image is filtered by a 2-dimensional convolution filter 18 and the output of the filtered image is stored in an output image buffer 19. The output image buffer 19 is scanned out by display electronics 20 to a video display device 21 for viewing.

A range of lens types can be accommodated to support various fields of view. The lens optics 11 may correspond with the mathematical coefficients used with the X-MAP and Y-MAP processors 16 and 17 to transform the image. The capability to pan and tilt the output image or images remains even though a different maximum field-of-view is provided with a different lens element.

The invention can be realized by proper combination of a number of optical and electronic devices as described in the 5,185,667 patent whose disclosure is expressly incorporated herein. Figure 1B contains elements similar to that of Figure 1A but is implemented in a personal computer represented by dashed line D. The personal computer includes central processing unit 15' performing the perspective correction algorithms X-MAP 16' and Y-MAP 17' as stored in RAM, ROM, or some other form. The display driver 20 outputs the perspective corrected image to computer display monitor 21'.

The transformation portion of the invention as described has the capability to pan and tilt the output image through the entire field-of-view of the lens element by changing the input means, e.g.



a joystick, computer, mouse, head tracker goggles, a chair with motion control, etc., to the controller. The image can also be rotated through any portion of 360 degrees on its axis changing the perceived vertical of the displayed image. This capability provides an ability to align the vertical image with the gravity vector to maintain a proper perspective in the image display regardless of the pan or tilt angle of the image. The invention also supports modifications in the magnification used to display the output image. This is commensurate with a zoom function that allows a change in the field-of-view of the output image. The magnitude of zoom provided is a function of the resolution of the input camera, the resolution of the output display, the clarity of the output display, and the amount of picture element (pixel) averaging that is used in a given display.

According to one embodiment of the present invention, the above-described imaging system can be used to provide spherical video images in a theater environment, as illustrated in Figure 2. The video images and audio signals are captured by the camera system (not illustrated) and then stored in the input image buffer 14. A computer 50, such as the personal computer D illustrated in Figure 1B is connected to the input image buffer 14 for receiving a stream of video images and audio signals from the input image buffer 14.

The computer 50 is also connected to at least one of a plurality of input control devices such as a mouse 52, a joystick 54, a remote control 56, a computer control 58, etc. The computer can also be connected to a pair of goggles 60 that track the movement of a user's head and/or a chair 62 with motion control. Example sensing systems include the use of gyroscopes, accelerometers, optical sensors, radio frequency sensors, and the like which are well known in the art. Each of these input control devices provides position feedback information to the computer 50. The position feedback

information provides an indication of the portion of the whole image that the user is interested in or desires to view. In addition, the input control devices can also cause the system to zoom in or out of a displayed image.

It is appreciated that a variety of different image formats may be used to store the spherical image. Formats that may be used include equirectangular, Mercator, side-by-side conical, single conical, bi-hemispherical, single hemispherical (and as disclosed in U.S. Patent Nos. 5,684,937, 5,903,782, and 5,936,630 to Oxaal), cubic, and other known image projection mappings as are known in the art. Additional file formats are disclosed in U.S. Patent Application Serial No. \_\_\_\_\_ (01096.84594) filed herewith and whose contents are expressly incorporated herein by reference.

The computer 50 is also connected to a projection system 64. The projection system 64 can comprise a single or multiple projection systems, front and/or rear projection, flat panel, monitor, display goggles, head mounted display, head-enveloping viewing systems (e.g. flogiston), etc. The projection system 64 also comprises a sound system for creating an impression of a three-dimensional sound field which coincides with the projection of the video images. In the alternative, the computer 50 may be connected to a separate sound system which creates the three-dimensional sound field.

A variety of display systems can be used as illustrated in Figures 8A-8G. For example, the display system can be selected from a computer CRT, television, projection display, high definition television, head mounted display, compound curve torus screen, hemispherical dome, spherical dome, cylindrical screen projection, multi-screen compound curve projection system, cube cave display, polygon cave display, or a virtual reality display system. The equations for transforming

images between representations are known in the art and are not treated here.

The operation of an imaging system according to one embodiment of the invention will now be described with reference to Figure 4. First, the video images and audio signals are captured in step 701 by a camera system like the one described above. The video images and audio signals may depict live and continuous action being captured by the camera system. The video images and audio signals are then sent to the input image buffer 14 in step 703 by a communications link 51. The communications link 51 can be, for example, a cable, phone line, wireless communication link or any other device capable of transmitting signals from the camera system to the input image buffer 14.

The user may indicate a desired direction of view using a variety of input controls to create position feedback information relating to the direction of the desired view in step 705. For example, the user may be wearing goggles which monitor changes in the position of the user's head as a means for creating the position feedback information. This system may use accelerometers to detect head movement. Likewise, the user may be sitting in a chair which is capable of changing positions and thus changing the direction of view of the user. This system may use optical sensors in the chair to detect movement. The user can also be using a mouse, joystick, remote control, computer control, etc., as a means for indicating the user's desired direction of view. Alternatively, feedback information may originate from another user with the current user acting as a spectator. The ability to control another's direction of view enables business applications such as providing tours of environments. Further, the feedback information may be stored and played back in place of a current user's feedback information. Previously stored position information is described in U.S. Patent No.

5,764,276 which is expressly incorporated herein by reference.

The video images and audio signals may be sequentially sent to the computer 50 in a stream in step 707. In addition, the position feedback information is also sent to the computer 50 as it becomes available. The computer first converts the video signals into seamless spherical video images. The process for seaming images is disclosed in detail in U.S. Patent Application Serial No. \_\_\_\_\_ (Attorney Docket No. 01096.86949) entitled "Method and Apparatus for Providing Virtual Processing Effects For Wide -Angle Video Images" and U.S. Patent Application Serial No. \_\_\_\_\_ (Attorney Docket No. 01096.84594) entitled "Immersive Video Presentations" both of which are expressly incorporated herein by reference. At least a portion of the spherical video images are perspectively corrected based upon the position feedback information in, for example, the manner described above with respect to Figures 1A-1B. For example, only the spherical video images in the general vicinity of the users view need to be perspectively corrected. The position feedback information is used by the computer 50 to determine the user's direction of view or desired direction of view. Once the direction of view has been determined, the computer 50 perspectively corrects the images in the vicinity of the user's direction of view. Alternatively, the user may specify multiple viewing directions. The process for displaying spherical video is discussed in U.S. Patent Application Serial No. \_\_\_\_\_ (Attorney Docket No. 01096.84594) entitled "Method and Apparatus for providing Virtual Processing Effects for Wide-Angle Video Images" which is incorporated herein by reference.

Where a user specifies multiple directions of view, the resulting images may be displayed as two separate windows. Alternatively, they may be displayed as a split screen with one screen

reflecting a first direction of view and subsequent screens reflecting the other directions of view (e.g. DOV2, DOV3, DOV4, ...).

Once the perspectively corrected video signals have been created, the computer 50 then properly orients the audio signals to create the impression of a three-dimensional sound field which corresponds with the selected layout of the 360 degree video image in step 713. For example, if a waterfall is directly in the field of view of the user, then the sound signals must be oriented in such a manner that the sound of the waterfall seems to be coming from in front of the viewer, i.e., from where the waterfall is located relative to the direction of the user's view. In addition, if the user is zooming in on the waterfall, the computer needs to increase the sound of the waterfall. Likewise, the sound of the waterfall needs to decrease as the waterfall moves further away. Furthermore, as objects pass by on either the right or left of the direction of view, any sounds the object is making needs to seem like it is moving by on either the right or left of the user's direction of view. In addition, the sound levels of objects at different distances from where the user is "located" need to appear realistic. The processing of the sound in the computer 50, according to one embodiment of the invention is performed by software developed by Aural Semiconductor Inc. which incorporates at least some of the information disclosed in U.S. Patent Nos. 5,596,644, 5,729,612, 5,802,180, and 6,009,178 all of which have been incorporated herein by reference. It will be understood that other software can be used to create the impression of a three-dimensional sound field and the invention is not limited to the software developed by Aural Semiconductor Inc.

For example, spatialization of sound fields can be accomplished by filtering audio signals using filters having unvarying frequency response characteristics and amplifying signals using

amplifier gains adapted in response to signals representing sound source location and/or listener position. The filters are derived using a singular value decomposition process which finds the best set of component impulse responses to approximate a given target set of impulse responses corresponding to head related transfer functions. One method for providing an acoustic display disclosed in U.S. Patent No. 5,802,180 comprises the following steps. First, audio signals and direct signals representing one or more sources of aural information are received. One or more ambient signals representing ambient effects are also received. First signals are then generated in response to the audio signals. A plurality of filtered signals are generated by filtering the first signals with filters having respective unvarying impulse responses which are substantially mutually orthogonal. One or more output signals are generated in response to the filtered signals. For a display receiving a plurality of audio signals, a respective first signal is generated by combining the audio signals according to a respective set of weights adapted in response to the direction signals and the ambient signals. For a display generating a plurality of output signals, a respective output signal is generated by combining the filtered signals according to a respective set of weights adapted in response to the direction signals and the ambient signals. A method for providing an acoustic display disclosed in U.S. Patent No. 5,596,644 comprises the following steps. An audio signal representing an acoustic source is generated. Location signals representing the apparent location of the source are then generated. Two or more filters are then applied to the audio signals. A plurality of output signals are generated by amplifying the output of each filter using amplifier gains adapted in response to the location signal and combining the amplified signals.

Once the audio signals have been oriented to correspond to the orientation of the

perspectively corrected video images, the computer outputs the perspectively corrected video images and audio signals to the projection system. The projection system then displays the perspectively corrected video images on a display screen and the audio signals are broadcast so as to create the impression of a three-dimensional sound field in step 715.

An alternative representation of the sound information is shown in Figure 5. Spherical image 901 is represented as it would appear to a user at location 902. As a direction of view is where a user is presently looking, sound sources A and B need to be coordinated to reflect the current field of view. For simplicity, the radius of sphere 901 is set to  $r$ . As one zooms in to a noise source, the noise source should appear louder and other sources softer. Figure 5A shows direction of view at 903. This direction of View (DOV) has a low zoom (or magnification) factor. Here, the noise sources A and B have approximately the same normalized volume as the audible distance from 903 to A and 903 to B are about the same. As a user zooms in on the perspectively corrected image, the DOV remains the same (906), but the zoom factor increases. The distance to points A and B decreases and therefore the sound from A and B needs to increase. However, as the DOV 906 is closer to A than B, a weighting factor applied to A reflects the virtual location of the viewer getting closer to A than . As perceived sound volume is inversely proportional to the distance from the noise source, the equation for sound from point A is used:

$$V_{(A)} = \frac{1}{d^2}(A)$$

Using a radius of 1 for sphere 901, the radius of a sphere at a first zoom (903) may be .2 for example. The radius at the second zoom (904) may be .4. The radius at the third zoom (905) may be .6. As the viewer zooms in, the sound from point A increases over the sound from B. The change in volume of A may be represented by the change in weighting factor for A.

$$\frac{V_{A(904)}}{V_{A(903)}} = \frac{\frac{A}{(\text{distance from } A \text{ to } 904)^2}}{\frac{A}{(\text{distance from } A \text{ to } 903)^2}}$$

$$\frac{V_{A(904)}}{V_{A(903)}} = \frac{(\text{distance from } A \text{ to } 903)^2}{(\text{distance from } A \text{ to } 904)^2}$$

Thus, as a user zooms in, the sound level emanating from a source close to the DOV increases and the sound emanating from a source opposite the DOV decreases. For two sources close to one another, the sound increases for both of them. This may be modified to weight more highly the sound sources directly within the DOV. Figures 5B and 5C show similar triangles that may be used to determine the ratio of sound from A/B.

The system and method and viewing environment described herein may also be applied to non-spherical video images as well. For example, systems exist (e.g. QTVR by Apple) that primarily concentrate on cylindrical images, where the top and bottom portions of an environment are removed or not captured. The designation of sound locations within a spherical image is similar to that described above. For example, a sound source may be located within the field of view of a user.



Also, the sound source may be located in a position not viewable by a user. For example, the sound source may be located directly overhead. In this example where one is limited to only a panoramic view eliminating the top and bottom of the image (e.g., top 10 degrees and bottom 10 degrees) zooming around the environment would still produce an effect similar to that as shown in Figures 5A-5C. Accordingly, it is therefore appreciated that the above described aureal technique may be applied to images containing a spherical data set as well as images containing less than a spherical data set.

The following disclosures are filed herewith and are expressly incorporated by reference for any essential material:

1. U.S. Patent Application Serial No. \_\_\_\_\_, (Attorney Docket No. 01096.86946) entitled "Remote Platform for Camera";
2. U.S Patent Application Serial No. \_\_\_\_\_ (Attorney Docket No. 01096.86949) entitled "Method and Apparatus for Providing Virtual Processing Effects For Wide -Angle Video Images"; and
3. U.S. Patent Application Serial No. \_\_\_\_\_ (Attorney Docket No. 01096.84594) entitled "Immersive Video Presentations".

While a preferred embodiment has been shown and described, it will be understood that it is not intended to limit the disclosure, but rather it is intended to cover all modifications and alternate methods falling within the spirit and the scope of the invention as defined in the appended claims. All of the above referenced U.S. patents and pending applications referenced herein are expressly incorporated by reference.

We Claim:

1. An image displaying system, comprising:
  - a projector for projecting composite video images on a screen, wherein at least a portion of said composite video images are perspective corrected spherical video images; and
  - a speaker system for creating an impression of a three dimensional sound field which corresponds to the orientation of said perspective corrected spherical video images.
2. An image projection system, comprising:
  - a processor;
  - a memory for storing video images and audio signals from a camera system wherein said video images correspond to at least two partial spherical video images, and said video images and audio signals are supplied to said processor;
  - means for tracking direction of view of a user provide position feedback information to said processor;
  - said processor comprising means for converting said video signals into seamless spherical video images, and means for perspective correcting at least a portion of said spherical video images based on said feedback information, wherein said feedback information provides an indication of a direction of view of the user;
  - means for projecting said perspective corrected video signals received from said processor on a screen; and
  - a speaker system for creating an impression of a three-dimensional sound field which corresponds to an orientation of said perspective corrected spherical video images.

3. The image projection system according to claim 2, wherein said screen is a flat screen.
4. The image projection system according to claim 2, wherein said screen is a compound curve torus screen.
5. The image projection system according to claim 2, wherein said screen is a hemispherical dome.
6. The image projection system according to claim 2, wherein said screen is a cylindrical screen.
7. The image projection system according to claim 2, wherein said screen has multiple screens.
8. The image projection system according to claim 7, wherein said multiple screens are compound curved screens.
9. The image projection system according to claim 7, wherein said multiple screens are cylindrical screens.
10. The image projection system according to claim 2, wherein said screen is a cube cave display.
11. The image projection system according to claim 2, wherein said screen is a spherical dome.
12. The image projection system according to claim 2, wherein said screen is a polygon cave.
13. The image projection system according to claim 2, wherein said perspective

corrected spherical video signals are displayed on a virtual simulator.

14. The image projection system according to claim 2, wherein head tracker goggles are used to track the direction of view of the user.

15. The image projection system according to claim 2, wherein seat motion control is used to track the direction of view of the user.

16. The image projection system according to claim 2, further comprising:  
input control means for changing the orientation of said perspectively corrected spherical video images projected on said screen.

17. The image projection system according to claim 16, wherein said input control means is a mouse.

18. The image projection system according to claim 16, wherein said input control means is a joystick.

19. The image projection system according to claim 16, wherein said input control means is a remote control.

20. The image projection system according to claim 16, wherein said input control means is a computer control.

21. The image projection system according to claim 2, wherein said projection means is a single projection system.

22. The image projection system according to claim 2, wherein said projection system is a multiple projection system.

23. The image projection system according to claim 2, wherein said projection means has

front and rear projectors.

24. The image projection system according to claim 2, wherein sound levels of objects increases when said objects are in the direction of view.

25. The image projection system according to claim 2, wherein said video signals are live video signals.

26. A method for projecting perspectively corrected video images in a theater environment, comprising the steps of:

storing video images and associated audio signals, wherein said video images and audio signals are gathered by a camera system wherein said video images correspond to at least two partial spherical video images;

tracking a direction of view of a user to create position feedback information;

providing said position feedback information to a processor, wherein said position feedback information provides an indication of a portion of said video images that the view is interested in viewing;

providing said video images and audio signals to said processor;

converting said video signals to seamless spherical video images;

perspectively correcting a portion of said spherical video images based on said position feedback information;

orienting said audio signals based on an orientation of said perspectively corrected video images; and

providing said perspectively corrected video images and said oriented audio signals

to a projection system, wherein said perspectively corrected video images are projected on a screen and said oriented audio signals are broadcast to create an impression of a three-dimensional sound field.

27. The method for projecting perspectively corrected video images in a theater environment according to claim 26, further comprising the step of:

continuously monitoring said position feedback information and reorienting said perspectively corrected video images and said audio signals as said position feedback information changes.

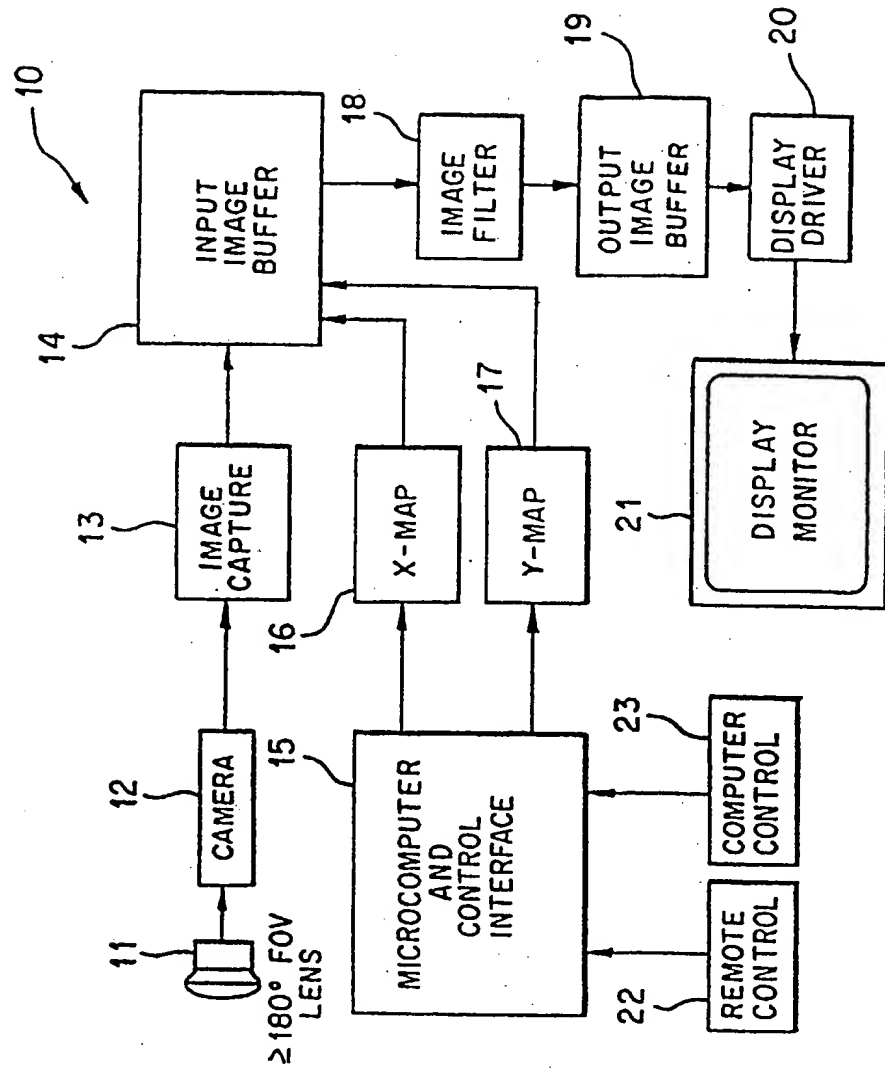


FIG. 1A

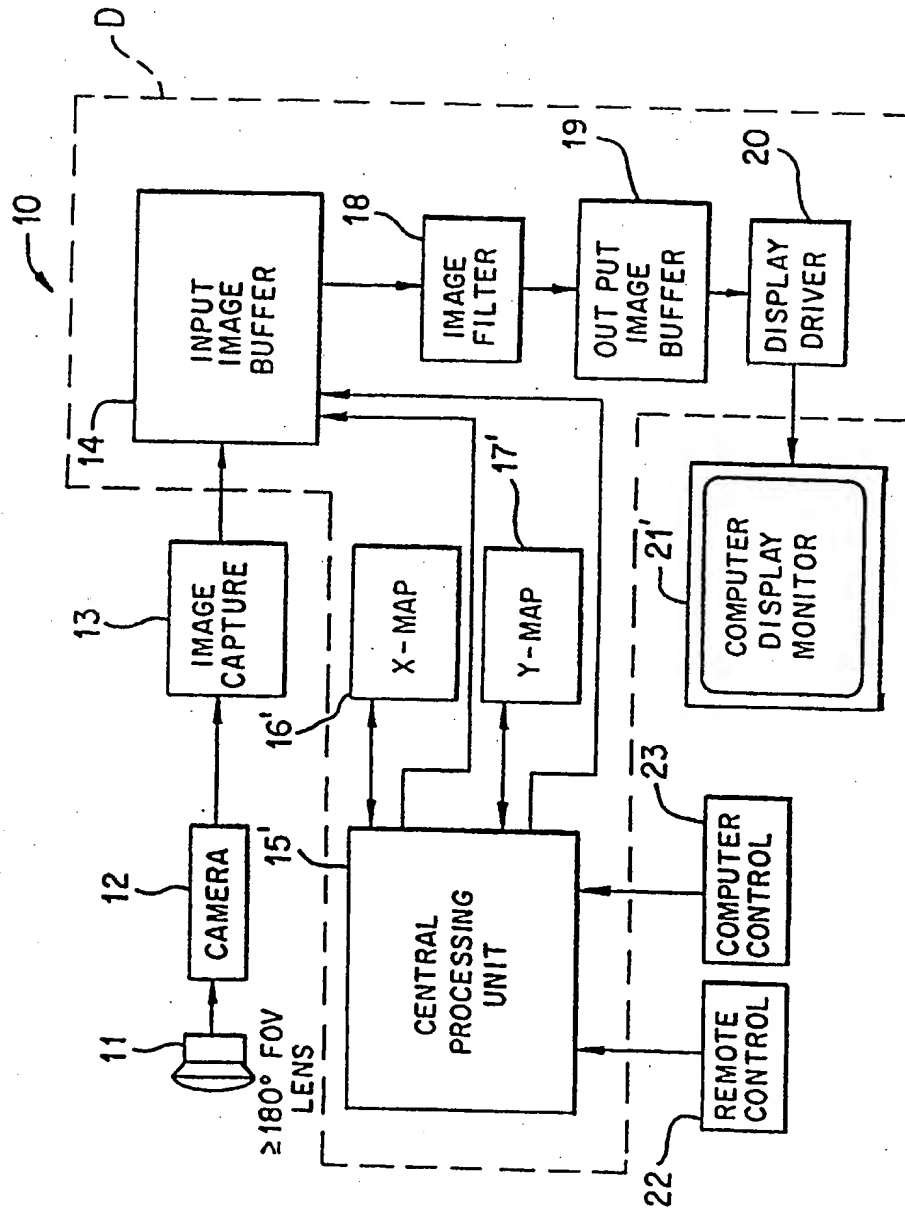


FIG. 1B



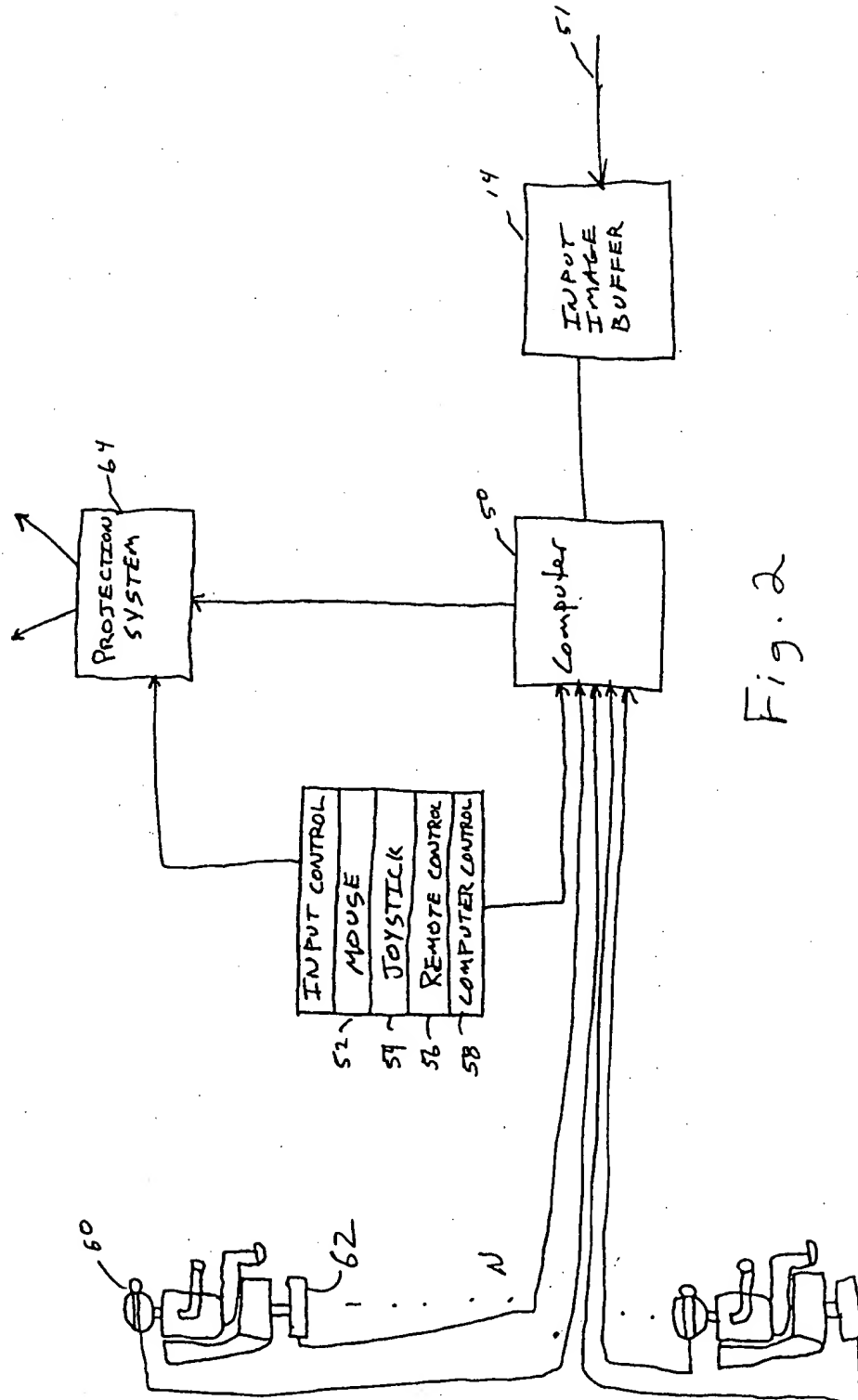
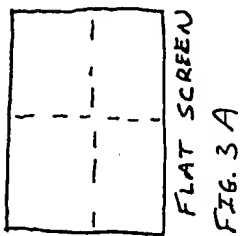
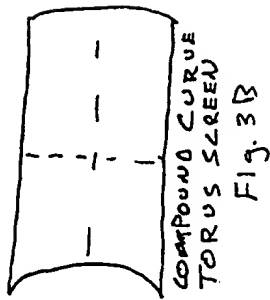


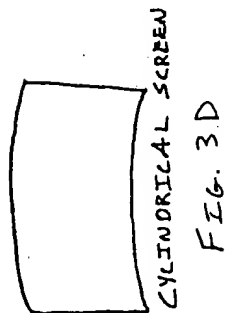
Fig. 2



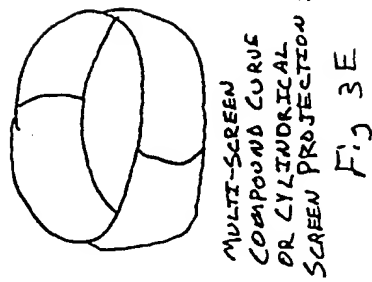
FLAT SCREEN  
FIG. 3A



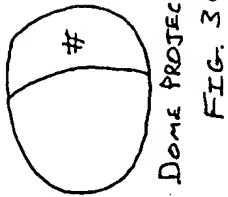
COMPOUND CURVE  
TORUS SCREEN  
FIG. 3B



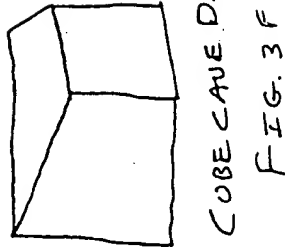
CYLINDRICAL SCREEN  
FIG. 3D



MULTI-SCREEN  
COMPOUND CURVE  
OR CYLINDRICAL  
SCREEN PROJECTION SYSTEM  
FIG. 3E



DOM PROJECTION  
FIG. 3C



CUBE CAVE DISPLAY  
FIG. 3F



POLYGONAL  
CAVE DISPLAY  
FIG. 3G

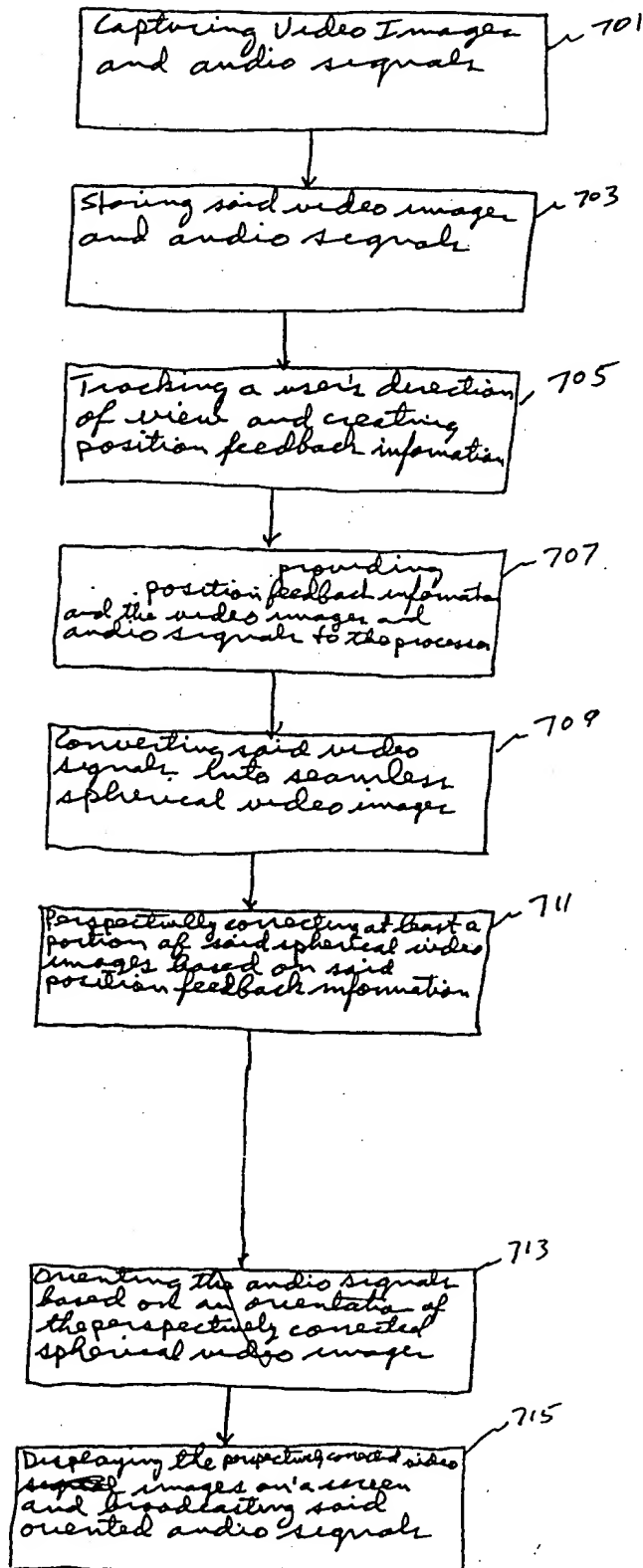


Fig. 4

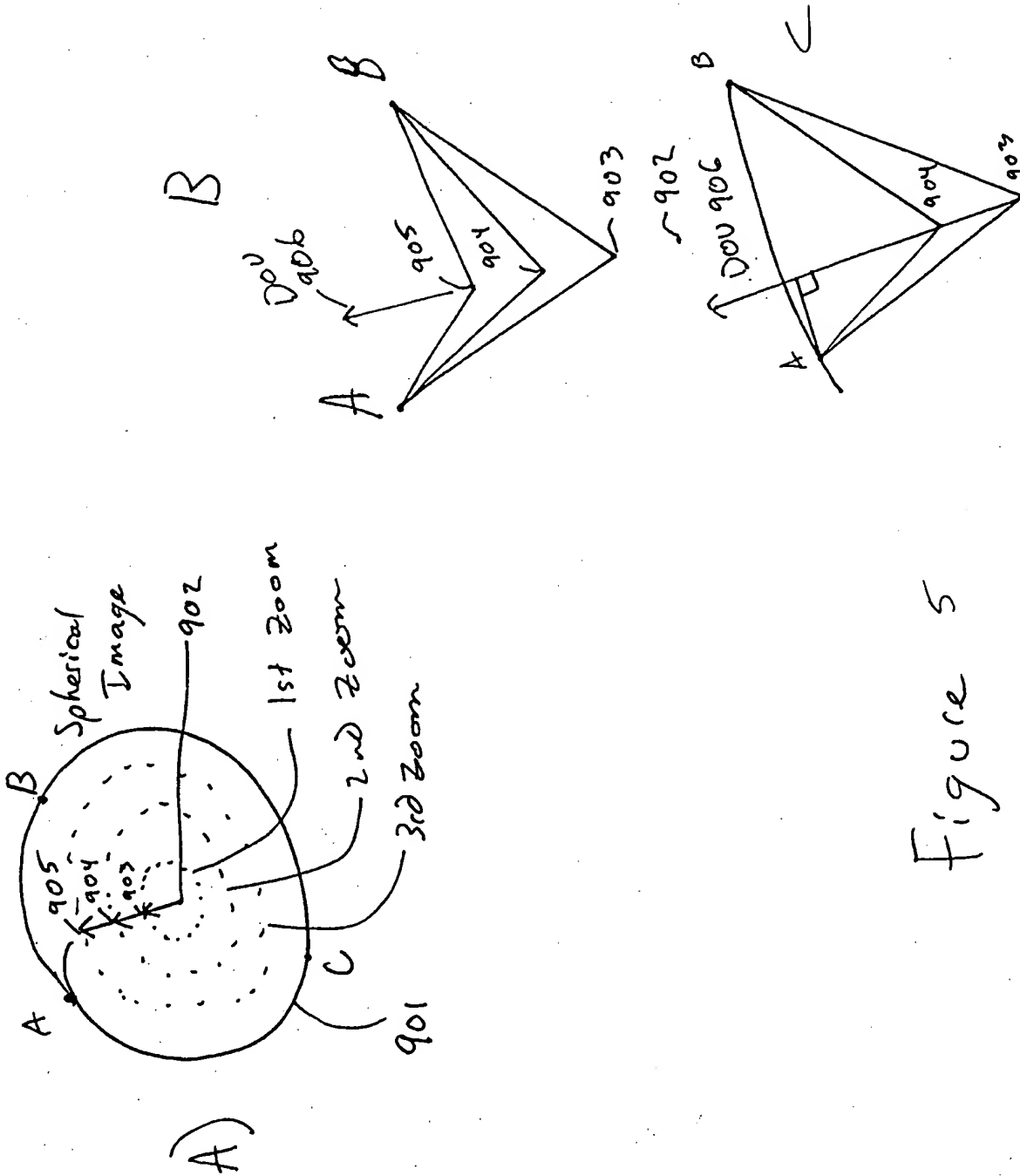


Figure 5

# INTERNATIONAL SEARCH REPORT

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 7 H04N5/74		International Application No <b>PCT/US 00/09462</b>		
According to International Patent Classification (IPC) or to both national classification and IPC				
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC 7 H04N				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) WPI Data, EPO-Internal, PAJ				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>				
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
X  Y A	WO 94 16406 A (RITCHEY) 21 July 1994 (1994-07-21) cited in the application abstract page 1, last paragraph -page 4, line 3 page 12, line 20 -page 14, line 26 page 15, last paragraph -page 16, line 10 page 35, line 14 - line 24 page 38, last paragraph -page 39, line 17 page 44, line 11 - line 33 page 49, line 15 - line 26 page 60, last paragraph -page 61, line 6 --- -/--	1-14, 22, 24-27  16-20 21		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <span style="margin-left: 100px;"><input checked="" type="checkbox"/> Patent family members are listed in annex.</span>				
* Special categories of cited documents :				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;">                     *A* document defining the general state of the art which is not considered to be of particular relevance                      *E* earlier document but published on or after the international filing date                      *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)                      *O* document referring to an oral disclosure, use, exhibition or other means                      *P* document published prior to the international filing date but later than the priority date claimed                 </td> <td style="width: 50%; border: none; vertical-align: top;">                     *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention                      *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone                      *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.                      *8* document member of the same patent family                 </td> </tr> </table>			*A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *8* document member of the same patent family
*A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *8* document member of the same patent family			
Date of the actual completion of the international search  <div style="text-align: center; font-weight: bold;">28 July 2000</div>		Date of mailing of the international search report  <div style="text-align: center; font-weight: bold;">04/08/2000</div>		
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer  <div style="text-align: center; font-weight: bold;">Berwitz, P</div>		

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/09462

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 97 01241 A (OMNIVIEW) 9 January 1997 (1997-01-09) cited in the application	16-20
A	page 1, line 30 -page 2, line 37  page 8, line 13 - line 19 page 9, line 14 - line 17 page 30, line 31 -page 32, line 11 page 43, line 1 - line 34 ---	1-3,21, 25-27
A	US 5 130 794 A (RITCHEY) 14 July 1992 (1992-07-14) abstract; figures 25,31,32,36,46,49,52 column 8, line 62 -column 10, line 56 column 17, line 5 -column 18, line 36 column 20, line 22 - line 62 ---	1-14, 25-27
A	GB 2 289 820 A (GULLICHSEN ET AL.) 29 November 1995 (1995-11-29)  page 1, line 1 - line 5 page 2, line 5 -page 3, line 7 page 4, last paragraph -page 5, line 19 page 8, last paragraph -page 9, line 11 page 19, line 1 - line 7 ---	1-3,14, 16-21, 25-27
A	US 5 657 073 A (HENLEY) 12 August 1997 (1997-08-12)  abstract column 2, line 7 - line 31 column 4, line 12 - line 57 ---	1-3,14, 16-21, 25-27
A	US 5 703 604 A (MCCUTCHEN) 30 December 1997 (1997-12-30) abstract column 1, line 40 -column 2, line 48 column 4, line 4 - line 9 column 8, line 59 -column 9, line 11 column 10, line 42 - line 56 column 11, line 10 - line 18 ---	1-3,14, 25-27
A	WO 96 13962 A (CRYSTAL RIVER ENGINEERING) 9 May 1996 (1996-05-09) cited in the application abstract page 6, line 24 -page 7, line 22 page 9, line 30 -page 10, line 7 page 11, line 8 - line 12 ---	1,2,14, 24,26,27
A	US 4 868 682 A (SHIMIZU ET AL.) 19 September 1989 (1989-09-19) figures 2,3 ---	5,6,22
	-/--	

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 00/09462

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>EP 0 522 204 A (MCCUTCHEN)  13 January 1993 (1993-01-13)  abstract; figure 18  -----</p>	6,11,22

# INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/US 00/09462

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9416406 A	21-07-1994	US 5495576 A	27-02-1996
WO 9701241 A	09-01-1997	US 5990941 A	23-11-1999
		AU 6386696 A	22-01-1997
		EP 0834232 A	08-04-1998
		JP 11508384 T	21-07-1999
		US 5764276 A	09-06-1998
		US 6002430 A	14-12-1999
US 5130794 A	14-07-1992	NONE	
GB 2289820 A	29-11-1995	US 5796426 A	18-08-1998
		JP 8079622 A	22-03-1996
		US 6005611 A	21-12-1999
US 5657073 A	12-08-1997	NONE	
US 5703604 A	30-12-1997	NONE	
WO 9613962 A	09-05-1996	US 5596644 A	21-01-1997
		AU 699647 B	10-12-1998
		AU 3969495 A	23-05-1996
		DE 69517192 D	29-06-2000
		EP 0788723 A	13-08-1997
		EP 0984667 A	08-03-2000
		JP 10508169 T	04-08-1998
		US 5802180 A	01-09-1998
US 4868682 A	19-09-1989	JP 2515101 B	10-07-1996
		JP 63008641 A	14-01-1988
EP 522204 A	13-01-1993	US 5023725 A	11-06-1991